Date of Submission	23 October 2020

IPL Project (IPL - 225) Annual Report Form 2020

1 January 2019 to 30 April 2020

1. IPL – 225 (approved 2017) Recognition of potentially hazardous torrential fans using geomorphometric methods and simulating fan formation.
2. Main Project Fields: (1) Technology Development: B. Hazard Mapping, Vulnerability and Risk Assessment
3. Name of Project leader: Professor Matjaž Mikoš, dr. sc. techn. ETH.
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   Core members of the Project: Assoc. Prof. Tomaž Podobnikar, PhD (UL FGG, 2017-18), Jošt Sodnik, PhD (UL FGG), Matej Maček, PhD (UL FGG), Mateja Jemec-Auflič, PhD (Geological Survey of Slovenia – GeoZS).
4. Objectives: The main goal of the research project was to develop methods for automatic determination and classification of torrential fans, with an emphasis on their potential use to recognize debris flow hazard in their catchment areas. The basic hypothesis was that by using a high-resolution DEM, and the characteristic spatial variables (indicators), it is possible to distinguish between torrential fans formed by debris flows and the alluvial fans where debris flows are rare events and where only fluvial torrential processes take place.
5. Study Area: Selected torrential fans in Slovenia to develop the model and the Sava Dolinka River valley in NW Slovenia to test the validity of the model.
6. Project Duration: 3 years (May 1, 2017 – April 30, 2020).
7. Progress Report: until the project's end in April 2020
   1) Progress in the project: The IPL-225 Project was approved in November, 2017. In the first phase, we focused primarily on the forms of torrential fans and their parts as geomorphological very complex forms of the Earth's surface. We tested different methods on complex terrain surfaces, such as new method for estimating fractal dimensions in 3D space (Babič et al., 2019a), and a new method of visibility network and statistical pattern network recognition (Babič et al., 2019b). The obtained results were promising, but such morphological methods need further refinement. Since one of the researchers left the research group to work outside Slovenia early into the project – only testing a GIS-based approach using FFT for karst relief cyclicity (Podobnikar et al., 2019) and not also for torrential fans, further research on the automatic determination and classification of torrential fans was not possible.

      In the field of rheology of debris materials, we tested rheological behavior of simple mixtures (fine-grained stone flour) in selected standardized laboratory environment (Marsh funnel, small

V-funnel) used for testing construction materials, such as mortar or cement, and coarser mixtures in another standardized laboratory environment (large V-funnel, L-Box). The results proved the applicability of such an approach in laboratory test apparatus, only the range of rheological properties of tested mixtures is not ideal - it was rather limited and close to rheological properties of typical fine-grained building materials and not as wide as can be found in natural environment. The results were summarized and presented in a MSc Thesis (Jurček, 2020). The idea is nevertheless to be followed and upgraded by mathematical modelling of such tests by applying numerical tools such as RAMMS::DEBRIS FLOW or the SPH method (Smoothed-Particle Hydrodynamics). Furthermore, the RAMMS::DF model was successfully used to reanalyze a case study of a debris flood in N Slovenia (Bezak et al., 2020).

2) Beneficiaries of Project for Science, Education and/or Society: The automatic identification of torrential fans as well as classification of their shapes using the geomorphometric analysis is a step further from the established procedures such as is the Melton number, which is calculated based on the morphological characteristics of the torrential watershed. The new approach included the development of several innovative methods of using DTMs as well as data mining techniques. Within the project we applied a numerical tool (RAMMS:DF) that can be used for torrential fan formation modelling – the catch 22 remains the determination (way of selection) of rheological parameters in the model in cases where no historical data are available on past debris flow events to validate the model for future scenarios. The project contributed to the development of the young geomorphometry domain as well as geo-informatics for the needs of water management, geology, civil engineering and, generally, geomorphology as a method used in various spatially oriented disciplines.

3) Results: Within the IPL-225 Project framework, the following publications were published:

Babič, M., Miliaresis, G., Mikoš, M., Ambu, R., Calì, M. (2019a). New method for estimating fractal dimension in 3D space and its application to complex surfaces. *International journal of advanced science, engineering and information technology*, 9, 6, 2154-2159, http://dx.doi.org/10.18517/ijaseit.9.6.9480.

Babič, M., Huber, M. A., Bielecka, E., Soycan, M., Przegon, W., Gigović, L., Drobnjak, S., Sekulović, D., Pogarčić, I., Miliaresis, G., Mikoš, M., Komac, M. (2019b). New method of visibility network and statistical pattern network recognition usage in terrain surfaces. *RMZ - materials and geoenvironment: Materiali in geookolje*, 66, 1, 13-25, http://dx.doi.org/10.2478/rmzmag-2019-0006

Bezak, N., Jež, J., Sodnik, J., Jemec Auflič, M., Mikoš, M. (2020). An extreme May 2018 debris flood case study in northern Slovenia: analysis, modelling, and mitigation. *Landslides*, 17, 10, 2373-2383, https://dx.doi.org/10.1007/s10346-019-01325-1

Jurček, T. (2020). *Laboratory analysis of natural debris material rheology: master thesis*. UL FGG, 76 p., https://repozitorij.uni-lj.si/Dokument.php?id=134206 (in Slovene with English abstract).

Podobnikar, T., Štefančič, M., Verbovšek, T. (2019). A GIS-based approach to karst relief cyclicity by using Fast Fourier transform. In: Kyroakidis, P. C. (Ed.). *Geospatial technologies for local and regional development*. AGILE; Limassol: Cyprus University of Technology, Department of Civil Engineering and Geomatics. 5 p.